Engineering Model of LST Being Assembled Here

FRANK J. CEPOLLINA, Goddard LST Engineering Model Manager shows Associate Administrator Dr. John E. Naugle (center) an LST mirror caging mechanism, one of 24 to be mounted under the 10-foot-diameter mirror. At right is Joseph Purcell, LST Study Manager. Dr. Alois W. Schardt, Deputy Director of Physics and Astronomy Programs is behind Dr. Naugle.

A full-scale engineering model of a space telescope that someday will look to the edge of the universe is being assembled in the high bay area of Building 5.

When fully assembled late this summer, the model will tower 41 feet and weigh 22,000 pounds. It is being built to permit development of the long lead-time technology needed to insure success of the operational Large Space Telescope (LST) scheduled to be launched by the proposed Space Shuttle in the 1980s.

Thus far, the spacecraft transition ring and instrument structure are here. The ring, largest titanium forging ever made, weighs 1,600 pounds and measures 11 feet in diameter.

The telescope portion of the model, housing a mirror ten feet in diameter, is a cylinder made of titanium alloy–the largest all-welded titanium alloy structure ever built. It is 30 feet long.

LST will be an unmanned "free-flying" spacecraft which can be "launched" from a shuttle vehicle and retrieved for repair or refurbishment. It is the first spacecraft designed to be launched and serviced by the proposed Space Shuttle.

Operating above the obscuring and distorting effects of the Earth's atmosphere, LST will be able to look ten times farther into the universe than is presently possible from the largest Earth observatories. With this increased viewing potential it is expected that astronomers will be able to determine whether the universe has a curvature or whether it is finite.

(See Page 2)

GODDARD NEWS
April 1972 Vol. 20, No. 1

Delta 88 Launches ESRO's Thor-Delta 1A

Goddard's Delta 88 soared majestically into the foggy skys of California at 8:55 p.m. (EST), March 11, carrying the 1,038-pound Thor-Delta 1A astronomical observatory into a near perfect polar orbit. It marked Delta's 81st success–a new record for NASA booster rockets.

A project of the ten-nation European Space Research Organization, TD-1A is the largest and most advanced satellite ever built in Western Europe. Its seven scientific experiments are investigating energy coming from stars and galaxies in an effort to solve some of the fundamental problems of cosmology.

The mission is controlled from ESRO's European Space Operations Center at Darmstadt, West Germany.

Delta 88 was the last to fly the conventional radio guidance system. Future Deltas will carry the Delta Inertial Guidance System (DIGS), a new self-contained system, according to Project Manager William R. Schindler.

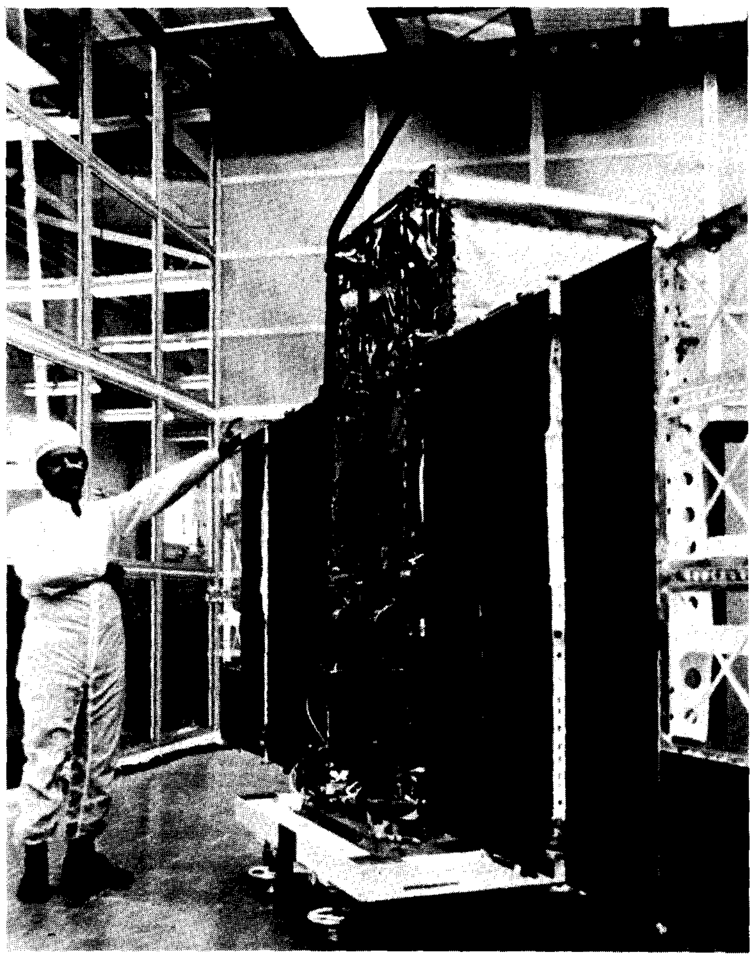
TD-1A was the sixth ESRO satellite to be launched by NASA. ESRO will reimburse NASA for the cost of the Delta and related launch and support services.

Goddard support for the mission included, in addition to the Delta, initial tracking during early orbital phases of the mission, and orbital computation.

Goddardites at the launch site–the Western Test Range, Lompoc, California–included Mr. Schindler, Robert Goss, NASA's TD-1A Project Manager; Charles Gunn and George Baker of the Delta Project Office and Lloyd Williams, Program Engineering Section of the Test and Evaluation Division.

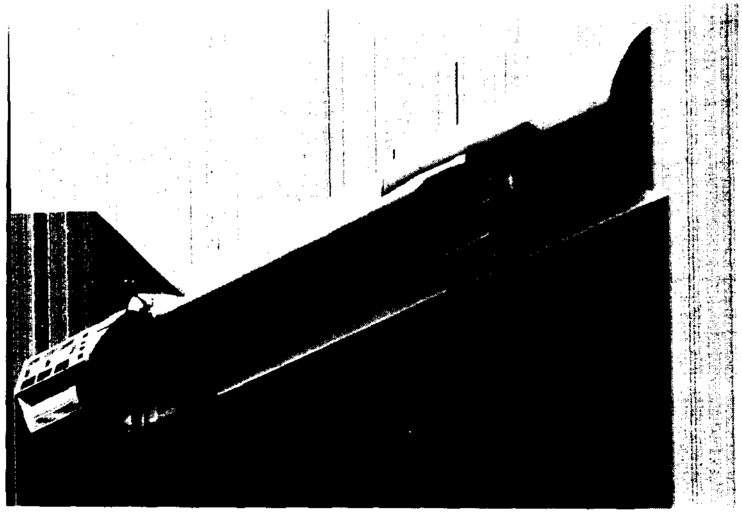
Key ESRO officials and 10 reporters from the European press witnessed the highly successful launch.

(See Page 5)

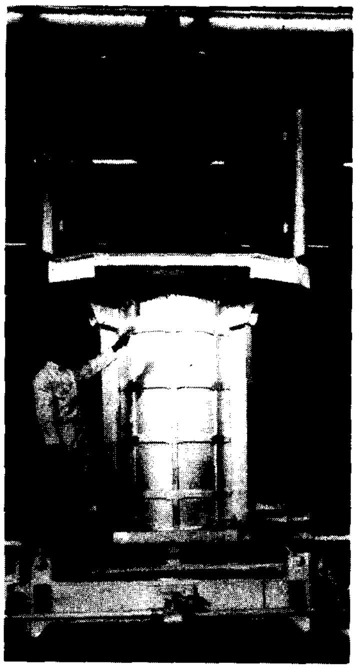


ESRO ENGINEER stands beside prototype model of the seven-foot-tall Thor-Delta 1A astronomical observatory satellite, at NASA's checkout facility, Western Test Range, Calif.

LST . . . From Page 1



ARTIST'S CONCEPT of LST in orbit. Cutaway shows secondary mirror location.



HENRY ERNST, Experimental Fabrication and Engineering Division, shows components of lower portion of LST engineering model being assembled here. Top ring is largest titanium forging ever made. The model is mounted on engine dolly surplus from cancelled SST program.

LST scientific objectives are directed at solving basic problems of modern astronomy and cosmology. They include studies related to:

- The evolution of galaxies and quasars,
- Density and composition of matter in the universe,
- The structure of asteroids and cometary centers,
- The composition of stars and neighboring galaxies,
- The physical nature of pulsars.

The LST model being assembled at Goddard is presently earmarked to fly on the third Space Shuttle mission as an attached facility to permit an evaluation of the viewing capability of the telescope mirror. The purpose of this flight is to determine if deformations in the mirror are caused by the Earth's gravitational forces when it is ground and polished. This "zero-G" experiment will thus help to properly calibrate the optical system for LST operational missions.

Cost of building the LST test model—estimated to be less than $1.5 million—has been kept down by the use of surplus titanium from the cancelled SST program. In addition, surplus ground support equipment from both the SST and Apollo programs—engine dollys and test stands—has been adapted for the assembly job.

After the LST model is assembled, a comprehensive test program will be undertaken at both the Goddard Space Flight Center and the Manned Spacecraft Center in Houston, to prepare the model for its zero-G Space Shuttle flight and to train astronauts in deploying, retrieving and changing subsystems during LST operational flights.

Goddard's more than ten years' experience in the field of space astronomy highlighted by the Orbiting Astronomical Observatory successes accounts for the Center's deep involvement in development of LST technology.

Goddard people involved in the LST model work include Joseph Purcell, LST Study Manager, who is also OAO Project Manager; Frank J. Cepollina, LST Engineering Model Manager; Ewald Schmidt, telescope structural design; Walter Zemko, stress analysis; Clyde Morgan and Vince Conelli, telescope design; Gary Jones, dynamics and distortion analysis, and Gordon Fehnmann, spacecraft mechanical system.

Working on the assembly project from Maurice Levinsohn's Experimental Fabrication and Engineering Division are Charles Bayle, George Croft, Henry Ernst, Andrew Hazen, Clifford Link, Charles Moubray, Jr., Elmer Mountain, William Peed, Nicholas Piegari, Elijah Tankisley, Stuart Tull and Anthony Votta. Seven major aerospace firms are providing support for the project.

Annual Meeting

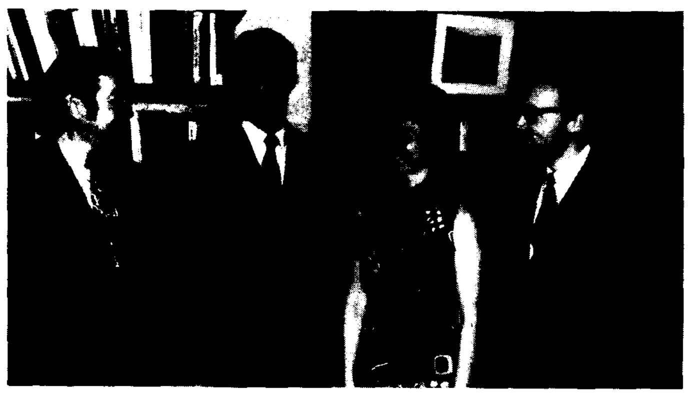
The fifty-third Annual Meeting of the American Geophysical Union will be held April 17 through 21, 1972, at the Sheraton Park Hotel in Washington, D.C. This meeting is usually attended by about 3000 scientists, and this year's program includes 1096 papers to be given in 98 scientific sessions.

A number of Goddard employees are involved with the program. Dr. Gilbert Mead of the Theoretical Studies Branch is the General Chairman for the meeting. Dr. Louis Walter, Head of the Planetology Branch, is Program Chairman for the AGU Planetology Section. About 70 papers will be presented by GSFC people. Of 93 invited papers, the following six will be presented by Goddard employees: "The Geomagnetic Field vs. the IGRF" by Dr. Joseph C. Cain, "High-Latitude Electric Fields" by Dr. James P. Heppner, "Electron Precipitation Patterns and Substorm Morphology" by Dr. Robert A. Hoffman, "Preliminary Mariner 9 IRIS Results" by John C. Pearl, "Thermospheric Composition" by Hans G. Mayr, and "The Atmosphere Explorer Program" by Nelson W. Spencer.

A special section on "The Surface of Mars" will be chaired by Dr. Jaylee Mead of the Laboratory for Optical Astronomy. A Post-deadline session on early results from the Small Scientific Satellite (Explorer 45 successfully launched on November 15, 1971, is being organized by Dr. Robert Hoffman, SSS Project Scientist. About 12 papers, four by Goddard scientists, will be presented at this session.

Dr. Gilbert Mead has organized and will chair the general "Frontiers of Geophysics" session on Wednesday, April 19. Dr. Carl Sagan of Cornell University will speak on "Mars: The View from Mariner 9" and Dr. Aden and Marjorie Meinel of the University of Arizona will discuss "Is Solar Power an Energy Option?"

Scott Colloquium Speaker



APOLLO 15 COMMANDER David R. Scott (second from left) was guest speaker at a special Scientific Colloquium on Tuesday, March 14. Here he is greeted by Dr. John F. Clark (left), Goddard Director, and Dr. Jaylee Mead and Dr. Bevan French, members of the Goddard Scientific Colloquium Committee. During the Colloquium, Colonel Scott discussed "Field Geology Studies on the Lunar Surface" using slides taking during the Apollo 15 mission including the Apennine Mountain Front and Hadley Rille. He also spoke of the intensive geology training he and James B. Irwin received before the mission. Scott's talk before a full-house in the Building 8 Auditorium was carried to selected points on Center by closed circuit TV.

SYLVIA B. HOOVER, of the Network Facilities and Services Division, receives a *Silver Snoopy* award from *Astronaut Robert F. Overmyer.* Sixty-six individuals and 11 groups received awards during the special ceremony held March 17 to honor the men and women of Goddard's government/industry Apollo Team.

Astronaut Overmyer Presents Snoopy Awards

March 17, 1972, was a busy day for Astronaut Robert F. Overmyer. At 9:00 a.m. he was here at Goddard to present Snoopy Awards to 121 men and women of Goddard's Apollo Team. By noon, he had to be at St. Agnes Hospital in Baltimore for the unveiling of a space age technology spin-off that enables doctors to monitor the heartbeats of patients as they move about hospital corridors.

At Goddard, Major Overmyer presented Silver Snoopy pins and letters to 66 individuals and Group Citations to 11 teams. The awards went to government and industry employees whose outstanding performance on the job has contributed significantly to the safety of the crewmen and the success of Apollo missions.

The ceremony in the Building 8 Auditorium opened with a presentation by the Marine Color Guard, and included a welcoming speech by James Donegan in behalf of Tecwyn Roberts, Deputy Director of Networks; remarks by Dr. John F. Clark, Goddard Director; and a discussion of the Manned Flight Awareness Program by Ozro M. Covington, Director of Networks.

While presenting the awards, Major Overmyer, who has never been in space but who is a member of the Apollo 17 support crew, greeted each employee with a personal handshake. Each letter and group citation was signed by the Apollo Astronauts as a personal "thank you" for a job well done.

The Snoopy pins depict the Peanuts cartoon pup "Snoopy" as the watch dog of Apollo safety.

AL GANTT, of the Network Computing and Analysis Division, is congratulated by Ozro M. Covington, Director of Networks, on his admission to the exclusive Silver Snoopy Club.

COST REDUCTION AWARDS. Lawrence S. Harvey of the Procurement Division receives a citation and cash award from Dr. John F. Clark (left), Goddard Director, and Samuel W. Keller, Deputy Director of Administration and Management, during one of the Annual Cost Reduction Award ceremonies held on March 15. David Kayman (right), of the Network Facilities and Services Division, waits to receive his award. They were two of 18 Goddard employees to receive awards during the ceremonies.

Annual Cost Reductions Awards

Eighteen members of the Goddard Staff were honored during the Annual Cost Reduction Award Ceremonies held throughout the Center on March 15. Dr. John F. Clark, Goddard Director, presented the awards and congratulated each employee for quick thinking that significantly cut costs in Fiscal Year 1971. On hand to witness each ceremony were Ray Einhorn, Director of NASA's Cost Reduction Program; Eugene Wasielewski, Goddard Associate Director and Director of Goddard's Cost Reduction Program; Merl Hemphill, OSS Cost Reduction Representative; and Donald Friedman, Goddard Cost Reduction Officer.

Cash Awards and Certificates of Merit went to: **Lawrence S. Harvey** and **John A. Underwood**, both of the Procurement Division; **Henry D. Obler**, of the Mechanical Engineering Division; **Delos C. Dupree**, of the Plant Operations and Maintenance Division; **James J. Kerley, Jr.**, of the Test and Evaluation Division; **Lloyd G. Green**, of the ERTS/Nimbus Project; **John M. Thole**, OSO Project Manager; **William D. Putney** of the Space and Earth Sciences Computer Center; **Benjamin Seidenberg**, of the Engineering and Physics Division; **David I. Kayman**, of the Network Facilities and Services Division; and **John E. Liner**, of the Communications Division.

Commemorative Plaques went to **William P. Manuel**, **Michael J. Berzonsky**, and **John R. Hurd**, all of the Program Support Division; **William W. Jones**, TOS Project Manager; **Charles M. Hunter**, TOS Spacecraft Systems Manager; **Michael L. Kaiser**, of the Laboratory for Extraterrestrial Physics; and **Carl S. Moore**, of the Network Engineering Division.

LEONARD F. DEERKOSKI of the Antenna Systems Branch receives a check from Robert L. Owen, Chief, Network Engineering Division in the amount of $50.00 for his invention for a signal-to-noise ratio determination circuit. This invention consists of a signal-to-noise ratio determination circuit which can be easily implemented in existing phase lock receivers. It can provide a continuous monitor of signal-to-noise ratio, or in the case of diversity receivers, can be used to generate an optimum weighing factor for each channel independent of all other channels. This technique is particularly useful in diversity systems that experience noise as well as signal variations in their receiver channels.

A NEW DISPLAY in the OPSCON area of Building 14 will be in operation in time for Apollo 16. The lighted map and charts, designed to be clearly visible from the viewing areas, will give visitors the current status of the mission at a glance. The display features a map of the Goddard Network flanked by a list of mission events at the right and a representation of the Apollo data flow and current operations at the left.

APOLLO 16 LAUNCH APRIL 16

Apollo 16, scheduled for an April 16 launch, will devote its twelve-day duration to gathering additional knowledge about the environment on and around the Moon and about our own planet Earth.

During the three days two Apollo 16 crewmen spend on the lunar surface north of the crater Descartes, they will extend the exploration begun by Apollo 11 in the summer of 1969 and continued through the Apollo 12, 14, and 15 lunar landing missions. In addition to gathering samples of lunar surface material for analysis on Earth, the crew will emplace a fourth automatic scientific station.

An extensive array of scientific experiments in the orbiting command/service module will search out and record data on the physical properties of the Moon and near-lunar space and photographic images to further refine mapping technology. Additionally, the command module pilot will photograph astronomical phenomena in the distant reaches of space.

The Descartes landing site is a grooved, hilly region which appears to have undergone some modification by volcanic processes during formation. The Descartes region is in the southeast quadrant of the visible face of the Moon and will offer an opportunity to examine several young, bright-rayed craters created by impacts in the volcanic terrain.

John W. Young is Apollo 16 mission commander, with Thomas K. Mattingly flying as command module pilot and Charles M. Duke, Jr. as lunar module pilot. Young is a US Navy captain, Mattingly a Navy lieutenant commander, and Duke a US Air Force lieutenant colonel.

Young and Duke will climb down from the lunar module onto the lunar surface for three seven-hour periods of exploration and experimentation. A major part of the first EVA will be devoted to establishing the nuclear powered, automatic scientific station—Apollo Lunar Surface Experiment Package (ALSEP)—which will return scientific data to Earth for many months for correlation with data still being returned by the Apollo 12, 14 and 15 ALSEPs.

The second and third EVAs will be devoted primarily to geological exploration and sample gathering in selected areas in the vicinity of the landing site. As in past missions, the crew's observations and comments will be supplemented by panoramic, stereo, and motion picture photographic coverage and also by television coverage. Crew mobility again will be aided by the use of the lunar roving vehicle.

In lunar orbit, Mattingly will operate experiments in the scientific instrument module (SIM) bay for measuring such things as the lunar surface chemical composition, and the composition of the lunar atmosphere. A high-resolution camera and a mapping camera in the SIM bay will add to the imagery and photogrammetry gathered by similar cameras flown on Apollo 15. Mattingly will perform an inflight EVA during transearth coast to retrieve film cassettes from these cameras.

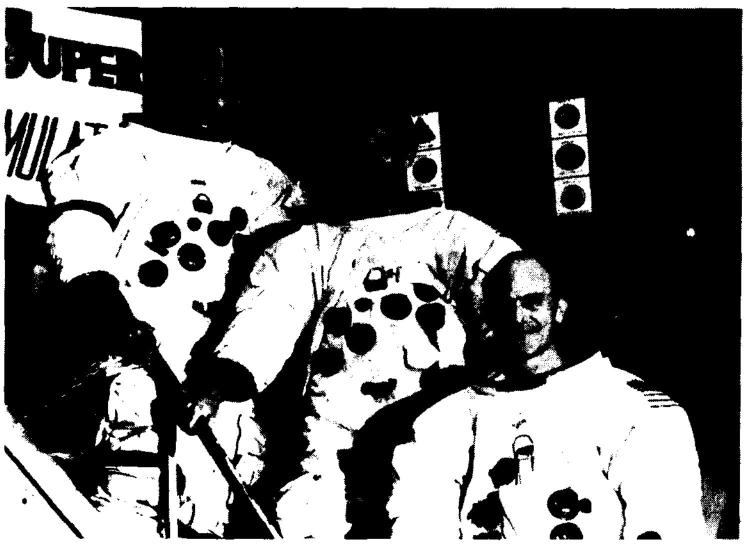
Using hand-held cameras, Mattingly will photograph such phenomena in deep space as the Gegenschein, and looking earthward, photograph the ultraviolet spectra around Earth.

A second subsatellite, similar to the one flown on Apollo 15, will be ejected into lunar orbit to measure the effect of the Earth's magnetosphere upon the Moon and to investigate the solar wind and the lunar gravity field.

Apollo 16 is scheduled for launch at 12:54 pm EST April 16 from the NASA Kennedy Space Center's Launch Complex 39, with lunar landing taking place on April 20. The landing crew will remain at Descartes for 73 hours before returning to lunar orbit and for rendezvous with the orbiting command module on April 23. Earth splashdown will occur on April 28 at 3:30 pm EST at 5 degrees north latitude and 158.7 degrees west longitude in the central Pacific just north of Christmas Island. The prime recovery vessel, USS Ticonderoga, an aircraft carrier, will be located near the splashdown point to recover the crew and spacecraft.

Communications call signs to be used during Apollo 16 are "Casper" for the command module and "Orion" for the lunar module. The United States flag will be erected on the lunar surface in the vicinity of the lunar module, and a stainless steel plaque engraved with the landing date and crew signatures will be affixed to the LM front landing gear.

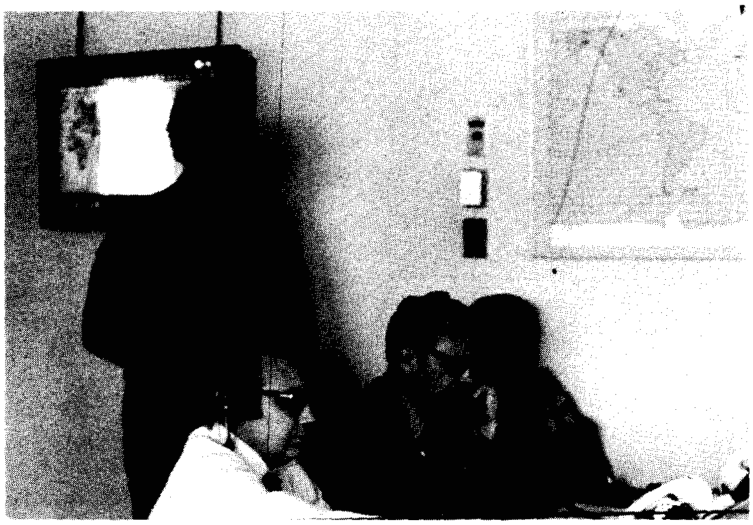
Apollo 16 backup crewmen are civilian Fred W. Haise, Jr., commander; USAF LtCol Stuart A. Roosa, command module pilot; and USN Captain Edgar D. Mitchell, lunar module pilot.



THE APOLLO 16 CREW pauses on the steps of the mission simulator during training exercises at the Kennedy Space Center. Standing (from the top) are Mission Commander John W. Young, Lunar Module Pilot Charles M. Duke, Jr., and Command Module Pilot Thomas K. Mattingly.

Delta. . . .From Page 1

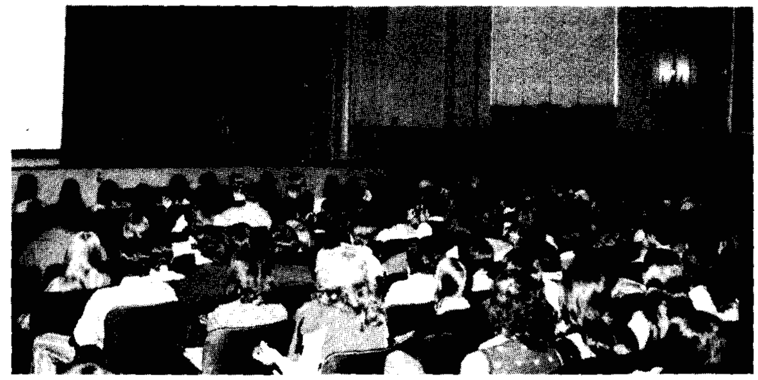
DR. T. O. HAMMARSTROM, Director of the European Space Research and Technology Center, and Bill Schindler, Delta Project Manager, discuss the successful launch of TD-1A at Mission Director's Center, Western Test Range.



MONITORING the TD-1A countdown in Mission Director's Center, Western Test Range, are seated (from left), Manfreid Grenseman of ESRO, Robert Goss of Goddard, NASA TD-1A Project Manager and Isaac T. Gillam, Delta Program Manager. Standing is George Baker of the Delta Project Office.

AFTER TD-1A WAS CONFIRMED IN ORBIT, ESRO officials sponsored a reception. In the foreground (from left) are Goddard's Bill Schindler; Pierre Blassell, ESRO; Henry R. Van Goey, Manager, NASA's Western Test Range Operations Division, Professor Werner Kleen, Past Director of the European Space Research and Technology Center (ESTEC), and Dr. T. O. Hammarstrom, ESTEC Director.

EPO in Connecticut



ASTRONAUT CHARLES G. FULLERTON describes NASA Space Shuttle Program to high school assembly in Stamford, Connecticut, as part of a "total impact" NASA orientation program sponsored by Goddard's Educational Programs Office. More than 16,000 students from 22 different schools participated.

Goddard's Educational Programs Office sponsored a highly successful two-week "total impact" NASA orientation program last month in Stamford, Connecticut, featuring Space Mobiles, lectures, exhibits and a visit by Astronaut Charles G. Fullerton.

The effort reached more than 16,000 students at 22 different schools.

In addition, 19,000 Stamfordites turned out to see a showing of NASA exhibits and hardware, according to Elva Bailey, Goddard Educational Programs Officer.

Participating in the program were Space Mobile lecturers Lawrence Bilbrough and Lawrence J. Costanza, both from Goddard, and George Pope from NASA Headquarters.

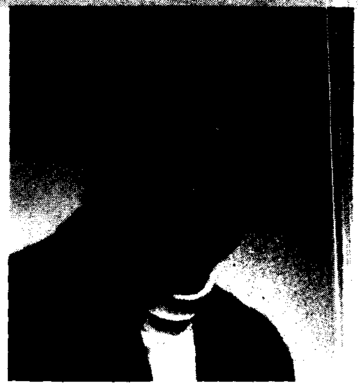
Student and civic response to the program was enthusiastic.

Astronaut Fullerton's one-day visit included talks at two Stamford High schools, a taped television interview by high school students and an address to the Stamford Lions Club where he received "keys" to the city from Mayor Julius M. Wilensky.

This was the fifth "total impact" program sponsored in the twelve-state, Northeastern U.S. area served by Goddard's Educational Programs Office. Cities where similar programs have been held include Baltimore, Maryland, Hershey, Pennsylvania, Buffalo, New York and Eastchester, New York.

SUITED FOR SPACE. Two New Jersey high school students, John Carchidi (left) and Thomas Whyte, visited Goddard on March 8 wearing space suits they made themselves. They are members of a space science club in Kearny, New Jersey. The club sponsor John O'Hara (standing) is assisting the students in the construction of a Skylab mockup. Also pictured are Margaret O'Hara and Raymond Villanova, teachers at the high school.

LLOYD PURVES, a data analyst in the Data Processing Branch of the Laboratory for Planetary Atmospheres, has been at Goddard since 1968 and does scientific programming for the IRIS Mariner Project. He has degrees in English and in Electrical Engineering from Union College, Schenectady, New York.



Processing IRIS Data from Mars

By Lloyd Purves

The encounter of Mariner 9 with the planet Mars on November 13, 1971 opens a new period in the exploration of our solar system This, the first planetary orbiter mission, gives us hitherto unavailable opportunities to extensively study a distant planet from close proximity. Because Mars. of all the other planets, seems to have the best chance of supporting life, the data returned by Mariner 9 have a special importance.

The dual mission of Mariner 9 is to survey about 3/4 of Mars and to provide intensive coverage of unique phenomena that might be detected. Goddard's part of the spacecraft is a Michelson infrared interferometer spectrometer, generally referred to as IRIS, for which Dr. Rudolf Hanel of Goddard's Laboratory for Planetary Atmospheres is the principal investigator.

The Mariner IRIS, constructed by Texas Instruments, is an advanced version of the IRIS instruments carried by Nimbus spacecraft. It measures infrared radiation from 200 cm^{-1} (50 μm) to about 2000 cm^{-1} (5 μm) at a resolution of 2.4 cm^{-1}. At Mariner's periapsis, IRIS views a circular area about 100 km in diameter on the Martian surface. After processing through the IRIS data system, the Martian infrared radiation recorded by IRIS yields a great deal of information on the temperature, composition, and structure of the planet's atmosphere and surface.

The IRIS data processing system begins in the instrument itself where there is a Hamming check code generator, designed by Warren Miller of Goddard. Sending data at the rate of 25 million bits a day across 70 million miles of space with an allowable error rate of one bit in a hundred thousand, the Mariner IRIS makes unprecedented demands on high speed, long distance, low error transmission techniques.

After the telemetry is received and recorded on tape it is processed by the Calibrated Spectra Program (CSP). This computer program decodes the interferograms and by comparisons with the Hamming code detects and corrects certain errors. It then Fourier transforms the interferogram to obtain an infrared spectrum, which in turn goes through calibration and is written on tape. Errors, in the case of IRIS, are more than normally critical since a single error in an interferogram can make the entire spectrum derived from the Fourier transformation uninterpretable.

The tape of calibrated infrared spectra then feeds into a second data system, the Science Analysis Program (SAP). Here the spectra are merged with orbital data and then analyzed to derive Martian surface temperatures, surface pressures, and atmospheric temperature profiles. Underlying SAP were many months of work invested in other supporting programs that synthesize the infrared absorption characteristics of the known Martian atmosphere and develop equations which can efficiently approximate these absorption characteristics. Iterative algorithms were then developed that derive Martian surface pressure and atmospheric temperatures by adjusting estimated pressures and temperatures until calculated infrared radiances approach measured values. To facilitate further analysis of the geographical and temporal patterns in the data, SAP also plots results and writes a summary of each solution and its orbital descriptors onto tape for global mapping and statistical analysis by other programs.

Aside from the computational challenges, certain operational aspects of this mission placed additional demands on the data analysis system. The primary portion of the mission, during which over 95% of the total mission data would be transmitted, was to last for only three months. After that, the depletion of attitude control gas and the loss of high gain antenna alignment cause science transmissions to be few and far between. At the time this article was being prepared, Mariner, which had transmitted an average of about 400 million bits of data a day during the primary mission, is transmitting only 50 million bits per day. The relative brevity of the important data acquisitions period required the IRIS analysis system be ready and working prior to encounter and able to produce interpretable results on a daily basis so that the science team at the Jet Propulsion Laboratory could optimize ongoing Mariner operations from the interpretation of current data. This entailed operating at the programs at JPL on an IBM 360/75 computer which was in many ways different from the Goddard SESD 360/91 and 360/75 computers on which the CSP and SAP programs were developed. A two hour per day limitation on IRIS computer time focussed extra attention on program efficiency, which was constantly improved through algorithm rearrangements, coding improvements, substitution of table look-ups for functions, and, in some cases, coding in machine language.

Harold Sagges
Data Analyst

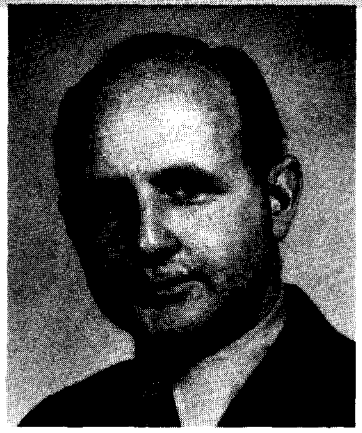
The outcome of these efforts has been highly rewarding. At JPL, the CSP and SAP programs produced about 20,000 transformed, calibrated, and analyzed spectra during the primary mission. Current data was available on a daily basis. This had special value when the Mariner orbital operation underwent numerous readjustments to cope with the effects of the unexpectedly severe Martian dust storm.

Among the many features of Mars that the IRIS experiment has revealed are the definite presence of water vapor on Mars, the surface pressure variations (i.e. differences in height of surface features), and the presence of silicon oxide suspended in the atmosphere during the dust storm. From a mapping analysis of the summary tape produced by the SAP, we now also have our first picture of the daily temperature behavior of the Martian atmosphere under both dusty and clear conditions.

People who have been closely connected with the programming effort are Ron Long, Ray Bevacqua and Willie Andrews of Consultants and Designers Inc. who wrote the Calibrated Spectra Program under contract to GSFC, Harold Sagges of Goddard who wrote the mapping program and produced the important coefficients describing the infrared absorption characteristics of the Martian atmosphere, and myself, who wrote the Science Analysis Program. Barney Conrath, Virgil Kunde and John Pearl, IRIS coexperimenters, developed the techniques used to extract Martian parameters. Virgil Kunde also directed the overall organization of the IRIS data system.

At this time the preliminary analysis phase can be considered fairly complete. The CSP and SAP programs now are being modified to improve results and many smaller, specialized programs are being applied in the data analysis effort. The results of the preliminary IRIS analysis have been published in *Science*, 21 January 1972.

SCIENCE AND ENGINEERING REPORTS



BOB FULCHER, an engineer in the Electro-Mechanical Branch, has been associated with the development of spacecraft control systems since coming to Goddard in 1962. Prior to his Goddard employment, he worked at Vitro Laboratories on the Polaris program and was a Communications Officer in the US Air Force. He holds Bachelor of Electrical Engineering and Master of Engineering Administration degrees from the George Washington University. He is a member of the IEEE.

S^3 Attitude and Spin Control Subsystem (ASCS)

By Bob Fulcher
S^3 Control System Engineer

Active magnetic control of the S^3 spacecraft recently played a major role in rescuing the badly coning spacecraft from peril, as previously reported in the *Goddard News*.

The action of magnetically torquing a spacecraft is somewhat analogous to a flea pushing against an elephant that is on a frictionless surface. The Earth's magnetic field provides a very convenient torquing means, but the torques are extremely weak (for example, magnetic circuits of electric motors operate with flux densities of ten-thousands of gauss, whereas the Earth's field is only a fraction of a gauss). When a spacecraft is maneuvered by generating on-board magnetic moments to interact with the Earth's field, a relatively long time is required to achieve desired effects (i.e., the flea will finally move the elephant significantly). But the advantages of magnetic torquing are, nevertheless, very potent. Only electrical power is required to achieve the momentum transfer and components can be very simple and highly reliable. Thus, in the case of the S^3 ASCS, much emphasis on the system design resulted in a subsystem compatible with the extremely meager weight and power resources available on-board this small spacecraft (the delivered ASCS weighed just 2.5 lbs. and required only 3.2 watts when energized). Moreover, the essentially electronic nature of the ASCS hardware components (as contrasted to gas tanks, associated plumbing and valves in competitive gas expulsion systems) made feasible the accommodation of the subsystem within the spacecraft.

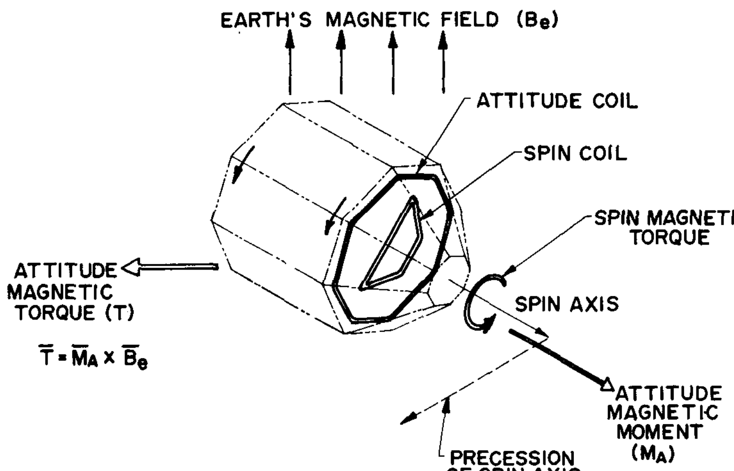
The system design of the ASCS incorporated many unique features to assure that the best possible subsystem would be supplied to the S^3 spacecraft. First, the spin control mode, which in effect is a very large diameter brushless DC motor, uses the highly efficient motor design techniques of saturated switching, current limiting by winding resistance and non-contacting commutation. In the case of spacecraft magnetic torquing, commutation of the spin coil (the "motor" winding) requires an instrument such as a magnetometer to detect the Earth's field (the "motor" field). The magnetometer used for S^3 deserves special mention. It was designed by Justin Schaffert, who did all of the detailed electronic design for the subsystem. The magnetometer's sensor occupied a fraction of the space usually required for such detectors, and the sensor is mounted directly to its electronics package. The whole magnetometer was located in a thermally unfavorable portion of the spacecraft and had to operate properly down to a temperature of -50°C.

The ASCS attitude control mode, which did not require commutation, incorporated all features of the spin mode, making it an equally efficient design (the attitude mode maneuvering is achieved by using the magnetic torque to precess the spacecraft's spin axis).

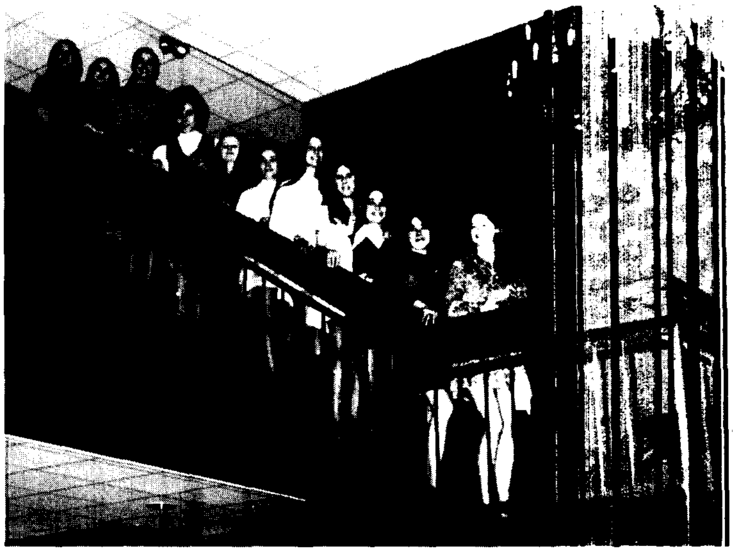
A further feature of the ASCS is automatic activation of the subsystem at selected orbit perigees. Because of the unique system design of the ASCS, this feature was provided with almost no additional complexity to the design. For the spin mode, it merely required setting the commutation trigger level on the magnetometer's signal to a value giving the desired "ON" time of about 44 minutes. (This was possible since the elliptical and equatorical S^3-A orbit provides an increasing, then decreasing field at the orbit perigee). Automatic turn-on of the ASCS attitude mode for selected perigees is similarly accomplished, and with the same circuitry, but does require the addition of a time constant circuit to keep the attitude coil energized constantly as the spacecraft rotates.

The testing of spacecraft magnetic torquing systems is a technology in its own right. Fortunately, Goddard's Test and Evaluation Division has an excellent magnetic test facility which provides controlled field environments around a spacecraft to simulate the field seen in orbit. The facility also includes sophisticated "torque-meters" to measure the flea-size torques developed by on-board magnetic torquing systems. The S^3 ASCS magnetic testing was directed by Joe Boyle of the Magnetic Test Section. A major economy in the S^3 testing, conceived by Joe and Bob Fulcher, was to support the spacecraft on a hinge fixture. This eliminated the need for an expensive non-magnetic dolly to support the spacecraft horizontally, while still providing full magnetic testing of the spacecraft by measuring the vertical components of the horizontal torques. The S^3 testing presented particular measurement challenges since the ASCS magnetic moments were relatively small and since the spin mode torques are pulsating with variable pulse-widths and pulse-amplitudes.

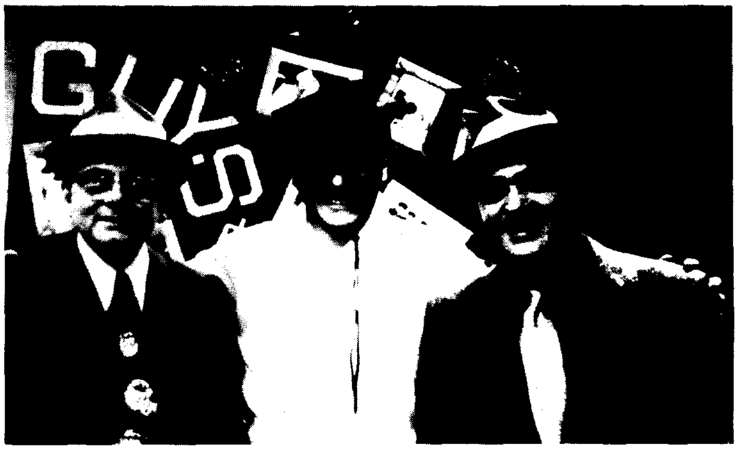
The S^3 ASCS has performed flawlessly in orbit. Since it has no known wear-out mode, the thousands of commands already sent to correct the unforeseen spacecraft dynamics problem should have no effect on its lifetime. The spin mode has been used to almost double the spin rate of the spacecraft from its nominal value of 4 rpm and the attitude mode has been used to maneuver the spacecraft's spin axis to achieve over 20 degrees change in the spin axis sun angle.



SPACECRAFT MAGNETIC TORQUING



WHICH ONE IS QUEEN? One of these Goddard gals was elected Goddard Queen for 1972 at the spring dance on April 7 (after this paper had gone to press). Back in February, the queen candidates were guests of the Ramada Inn in Lanham, Maryland, for a luncheon to promote the "Miss Ramada" Program. At the inn are (from top) Linda Veitch, Joyce Maria, Ann Patterson, Darlene Seiler, Teresa Faw, Cathy Fleshman, Pat Beach, Sandy Howard, Laurrie Weimer, Mary Ellen Shoe and Paula Cutler.



GUYS AND DOLLS. Three men from Goddard held key roles in the Burtonsville Players production of "Guys and Dolls" which recently completed four weekend performances at the Burtonsville Elementary School and one at Laurel High School. The Goddard Guys are Chuck Vest (left) as Benny Southstreet, Vince Arillo in a dual role as a member of the mission band and a Cuban dancer, and Jack Libby (right) as Nicely-Nicely Johnson. The Burtonsville Players, an amateur theatrical group, was organized in 1968 by the Burtonsville, Maryland, Elementary School PTA to raise money for needy organizations in their community. In the past four years, the Players have donated around $5000 to charity.

SAFE AWARD. Ed Fitch admires the new T&E SAFE parking sign as John New, Chief of the Test and Evaluation Division (T&E), taps it in place. At left is Adolf Lekebusch, T&E Safety Officer. Mr. Fitch was the first winner of the program to find and correct safety problems. His suggestion relating to the Launch Phase Simulator will entitle him to a reserved parking space in front of Building 7 for the month of April. SAFE suggestions are also screened for suitability for submission to the National Safety Council award program. Anyone having a suggestion pertaining to T&E operations is eligible for this award. Call extension 4747.

Co-op Paper Wins AIAA Award

TWO GODDARD CO-OP STUDENTS, Norman Starkey (left) and Ron Luzier, won first place in an Elective Research Paper Competition held by the Department of Aerospace Engineering at the University of Maryland and sponsored by the American Institute of Aeronautics and Astronautics (AIAA). The win entitles them to enter AIAA Middle Atlantic Research Paper Competition which will be held in May at Drexel University. Both students will graduate from the University of Maryland in June with degrees in Aerospace Engineering, and both have worked two semesters and one summer at Goddard. Norm was with the Delta Project, and Ron worked for the Test and Evaluation Division. Their paper on "Transient Response Analysis of the Thor-Delta Launch Vehicle at Liftoff Using the NASTRAN Finite Element Structural Analysis Program" was written at the university, but drew on their experience here at Goddard.

Reader's Views Welcome

What type of stories do you enjoy reading in the *Goddard News*? Do you like technical papers such as DATA TOPICS, articles about people, or general news about Goddard projects? Would you like to see a "Letters to the Editor" column or more social news?

With this first issue of Volume 20, we are inviting written comments from our readers. Some changes under consideration for the future include more stories on groups working on Center and special issues devoted to new projects. What would you like to see?

We cannot promise to act on all suggestions, and only letters of interest to all Goddard employees can be printed.

Letters should be addressed to Nancy Mengel or Patricia Ratkewicz, the Goddard News, Code 202.

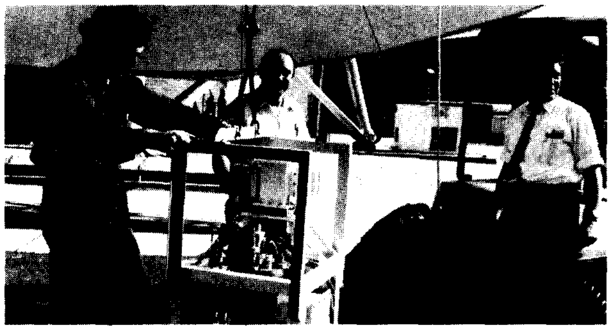
Goddard Mourns

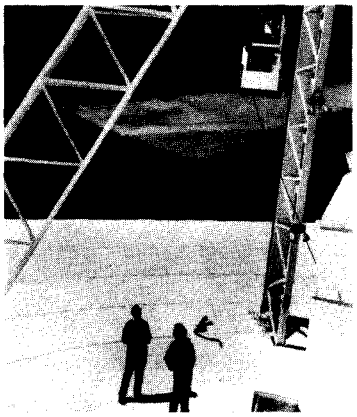
Marie deNovens died on March 18 following a heart attack. Miss deNovens first came to Washington in 1937, and served as a mathematician and physicist for the Bureau of Standards, the Naval Research Laboratory, and for Goddard before retiring in 1970.

Lewis Wexler, a Staff Engineer in the Network Development and Engineering Division, OTDA, passed away March 28 of a heart attack. Mr. Wexler had been in OTDA since May 1965. Before joining NASA he was employed as an engineer by the Department of the Navy as a construction management engineer.

GODDARD AROUND THE WORLD

MEET THE STATION DIRECTORS. Station Directors and key members of Goddard's Networks team are (from left) Dr. Luis Gopegui, Madrid; Chester Shaddeau, Santiago; Bill Shaffer, Associate Chief of the Network Operations Division; William E. Edeline, Tananarive; Jack Dowling, Merritt Island; Richard J. Augenstein, Assistant Chief of the Network Operations Division; John South, Quito; Ed Eisele, Alaska; Lawrence Odenthal, Grand Bahama; George Fariss, Goldstone; Wylie McMillan, Bermuda; Lloyd White, Corpus Christi; Mort Berndt, Madrid; Bill Wood, Chief of the Network Operations Division; Jeff Speck, Ascension Island; Willem Botha, Johannesburg; Otto Thiele, Vanguard; Virgil True, Hawaii; Donald Hearth, Goddard Deputy Director; Tecwyn Roberts, Deputy Director of Networks; Dennis Willshire, Orroral; Ozro Covington, Director of Networks; Chester Matthes, Fort Myers; C. Nicolson, Winkfield; Charles Rouiller, Canary Island; Ray Jacomb, Carnarvon; Don Gray, Honeysuckle Creek; and Chuck Jackson, Rosman. Not shown is Charles Force, Guam Station Director. The picture was taken during a recent conference at Sapphire Valley, North Carolina.





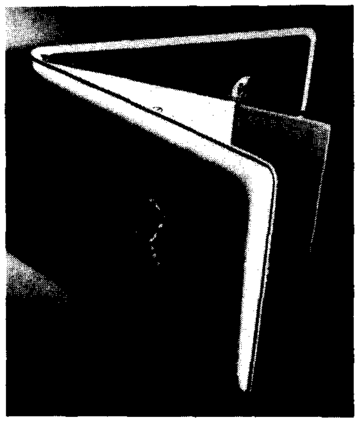
HONEYSUCKLE CREEK, AUSTRALIA. A maser was recently installed at the station. In the picture above, Tom Matlick (left), of Goddard's Unified S-Band Section; Len Litherland, HSC Operations; Ted Burt, and Jim Kirkpatrick (right) HSC Facilities; prepare the maser unit for lifting up to the feed cone of the 85-foot antenna. At right, the unit is lowered onto the face of the antenna.

WAYNE FOSTER, computer technician (left) and Jeff W. Speck, NASA Station Director at Ascension stand with a 243-pound yellowfin tuna which Mr. Foster caught off the island in December. It took Mr. Foster 25 minutes to play the huge fish up to the boat and another ten minutes for the entire boat crew to get it onboard.

THE GOVERNOR OF ST. HELENA, His Excellency Sir Thomas Oates, turns the antenna during a recent tour of the Devil's Ashpit station. Watching his performance are His Honor the Administrator of Ascension Island, Brigadier H. W. D. McDonald and Lt. Col. Malcolm McMullen (partly hidden), Director of Downrange Affairs, USAF. The station tour also included an Apollo 15 film and a game of blackjack against one of the station computers.

Special Apollo 11 Award

A DOLLAR-SIZED COIN containing metals from actual working components of the Apollo 11 spacecraft Eagle, which landed on the Moon, and the spacecraft Columbia, which orbited the Moon, was used in processing a medallion for the expressed use of the Manned Flight Awareness Program. At Goddard this medallion was presented to selected employees with a certificate of appreciation from Ozro M. Covington, Director of Networks, in the form of a unique picture-album/coin-booklet. Recipients of this attractive certificate were 5390 members of Goddard's government/industry Apollo Team whose work was directly related to the successful support of the historic Apollo 11 mission.



Convair 990 in Goddard Flights

By Alice Lohr
Meteorology Branch

One of NASA's Earth Observations Aircraft, the Convair 990 (Galileo), recently performed three missions for Goddard from Andrews Air Force Base. The Galileo's home station is the NASA Ames Research Center at Moffett Field, California. Prior to the Andrews flights several flights were made from Moffett and Ellington AFB, Houston, Texas, primarily for microwave investigations of agricultural test areas.

The first of the Andrews missions was to observe rough seas of the Atlantic off the coast of Maine. Ocean surface observations were made through various atmospheric conditions. The flight was a series of runs through a storm center, starting at the top of the clouds. Observations were made at a number of altitudes ranging from the 25,000 foot cloud top to approximately 500 feet. With all the valuable data acquired, the mission was considered successful. A point of interest during this flight was the discovery of a large oil slick on the surface of the ocean. In obtaining microwave signatures of the oil slick, the source was discovered to be a freighter, as suspected.

The second flight from Andrews was for mapping lake ice on Lakes Erie, Ontario, and St. Claire, and the Thousand Islands region of the St. Lawrence River. Weather and ice conditions were ideal for obtaining both photographic and microwave images. This was the first extensive survey of lake ice using microwave radiometry.

The "990's" third mission was a search over the Atlantic for sea surface temperature gradients. This flight was made over the warm tongue of the Gulf Stream under calm conditions. It was a most successful flight in that scientists were able to acquire great temperature variations from about 3°C. up to about 20°C.

The Flight Director for the NASA missions is Earl Petersen of NASA/Ames. The Expedition Scientist for these three missions was Dr. Per Gloersen of the Earth Observations Branch, Laboratory for Meteorology and Earth Sciences. Along with support personnel from Ames, Goddard personnel present for these missions were: Dr. Thomas Schmuggee, Dr. William Webster, and Roderick Carter of the Earth Observations Branch, and Dr. Thomas Wilheit, Ernest Hilsenrath, and Mrs. Alice Lohr of the Meteorology Branch.

BEFORE THE FLIGHTS, Phil Wilcox, a member of the flight crew, Dr. Thomas Wilheit (standing) and Mrs. Alice Lohr, of the Meteorology Branch pose with the typewriter she used to take down data as it was received by the experimenters.

RODERICK E. CARTER of the Earth Observations Branch monitors the 39.4 GHz downward looking radiometer with the L-Band microwave.

EXPERIMENT SCIENTIST Dr. Per Gloersen and Dr. William Webster (seated), both of the Earth Observations Branch, watch the instruments during flight.

ERNEST HILSENRATH uses the alum oxide hygrometer to measure ambient water vapor.

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